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Vol. III 1914 No. 1

Hybridization of Tobacco

By José Paredes Tirona.

Thesis presented for graduation from the College of Agriculture. No. 15.

The production of inferior tobacco by the Philippine natives is so great that if it is not checked it will continuously lead to a deterioration of yield and quality, and consequently there will be loss to the growers and detriment to the reputation of Philippine tobacco. This deterioration is partly due to the lack of improved varieties and failure to breed and select the varieties now at hand.

The object of my work has been to improve the native tobacco by breeding improved varieties which are adapted to local environment. There are two means by which new improved varieties may be established. The first is by selection alone, and the second by the combination of hybridization and selection. As a very striking example of the results attainable by the former method, we can cite the White Burley variety. This variety was produced by Mr. Webb of Ohio, in 1864. In his plantation of Red Burley, he noticed a few plants which possessed characters different from the rest. After he found that the cured leaves of these few individuals were superior to the Red Burley, he carefully saved the seed for the next season. Separate and careful culture was made with the few selected plants until a distinct variety was established.

Selection as the means of establishing improved varieties can only be practiced with great prospect of success when there is a big field to select from, because the bigger the field, the more chances there are to find desirable individuals or mutants. But since the College has only small experimental plots of tobacco, the idea of establishing improved varieties by selection has to be deferred.

Another reason why the writer did not prefer the first method is because only "the best that is in a variety can be brought out by selection;" but when the variety lacks the desired characters, the only remedy is to introduce new blood. For example, the selection of an ideal wrapper type from Cagayan tobacco would probably not be practicable, because this variety does

not possess great promise in this character. The only way to produce an ideal wrapper type from Cagayan is to introduce blood of real wrapper types, and this can only be accomplished by hybridization; which must be accompanied and followed by continuous and rigid selection.

PREVIOUS WORK ON THE SUBJECT

According to H. K. East, the earliest man to study plant hybrids was Kolreuter (1763). He made many crosses between the different species of Nicotiana, but his study was confined mostly to the botanical side.

Gärtner (*East—1912*) in his experiments (1849) found out that the hybrids of Nicotiana species grew very vigorously. He said, "Such species of hybrids as Nicotiana suavolenta macrophylla, and Nicotiana rustica marylandica reach a noteworthy height and circumference."

Focke (*East and Hayes—1912*), a contemporary of Darwin, noticed also the vigor of hybrids and said, "In size the hybrids generally surpass both the parental species or at least they surpass the average height of the two: compare many hybrids of Nicotiana, Verbascum and Digitalis." He further stated that, "The blossoms of hybrids often appear earlier than those of the parent species, for example, Nicotiana rustica paniculata, and especially many hybrids of Verbascum".

Naudin (*Focke—1881*) crossed a variety of tobacco with lanceolate leaves with a variety which produced broad oval leaves. The first generation did not vary much, but the difference was more marked in the second generation.

At the present time, the men who have done most on the improvement of types of tobacco by selection and hybridization are Shamel and his co-workers. Their work began about 1900. Shamel pointed out the benefit derived from selecting individuals and in breeding from their seed. By this method the yield of tobacco in the United States has increased in value, because it tends to produce more uniform and better types.

Shamel (1903) produced four new tobacco varieties, two of which were established by selection alone and the others by hybridization and selection. The following are the descriptions of the origin of the varieties:

"Uncle Sam Sumatra" originated in Tariffville, Connecticut, from a crop of Sumatra tobacco. Certain individuals were noticed by Mr. Shamel to be different from the rest. These individuals were bred and selected separately until a variety was established.

"Hazle Wood Cuban" originated in the same manner, from Cuban tobacco grown in the Connecticut Valley.

"Brewer Hybrid" was the progeny of the cross Cuban × Connecticut Broadleaf, grown in the Connecticut Valley. The hybrid is a cigar wrapper type.

"Cooley Hybrid" was the result of the cross between Sumatra and Connecticut Havana as mother parent. This is also a cigar wrapper type.

Dr. Louis Trabut of Algeria crossed some foreign varieties of tobacco with the native varieties, and secured some types better than the acclimatized native varieties.

Sherfflus (1904) of Kentucky obtained a hybrid between Standup Burley and Sumatra. The wrapper type hybrid did not show much improvement during the first year, but it did during the second.

Selby and Hauser (1904), of Germantown, made several crosses between Connecticut Broadleaf and Cuban varieties. Crosses were made also between these hybrids and Ohio Seedleaf and Zimmer Spanish × Cuban. Then during the following season crosses were made again between Zimmer Spanish, Ohio Seedleaf, Cuban and several already formed hybrids. The hybrids formed

were grouped into four classes for convenience: "first, includes the Havana or Spanish; second, contains the seedleaf class; third, those intermediate between seedleaf and Spanish, and fourth, Cuban and Connecticut Seedleaf hybrids." Of the hybrids selected, their average excess of yield per acre, over Zimmer Spanish, were as follows:

1908	189 lbs.
1909	227 lbs.
1910	405 lbs.

Shamel and Cobey (1906) recommended the following plan in using hybridization as one of the methods of breeding:

> "The best plan which can be followed in the case of crosses is to grow 100 plants of each cross and carefully note the characteristics of the hybrid plants. It will be found that there will be a considerable variation in the plants of the first season. Seed should be saved from those plants which are the most desirable and which show the greatest improvement over the native varieties. The next season a larger area can be planted from this seed; and if the crop is uniformly of the type desired, enough seed can be selected, the second season, to plant the entire crop the third year."

THE MATERIAL USED AND DESCRIPTION OF PARENTS.

The material used in this experiment consisted of Connecticut Broadleaf, Connecticut Havana, and Cagayan varieties. The imported varieties were from best selected seed, and the Cagayan variety was gotten from the Cagayan Valley, through Mr. Cagurangan. The imported varieties did not produce good wrappers, nor were they adapted to the local environment, but the native variety did very well at the College. The following descriptions show the important features of the parents.

CONNECTICUT BROADLEAF, NO. 973 (1)

The Broadleaf had an average height of one meter, and produced an average of sixteen long-pointed, drooping leaves. The length of the leaf was more than twice the width, and the leaf area, six square decimeters. The stem was about 8.5 centimeters in circumference, and had few small suckers.

CONNECTICUT HAVANA, NO. 974 (1)

The Havana had an average height of 1.7 meters and produced an average of nineteen medium, erect leaves, with slightly drooping tips. The leaf area was about five square decimeters. The stem was seven centimeters in circumference.

CAGAYAN, NO. 1496 (2)

The Cagayan had an average height of 1.7 meters, and produced erect, ovate-lanceolate leaves, with slightly drooping tips. In the circumference of the stem, average number of leaves and leaf area it was similar to Havana. It was well adapted to the College climate. Its only undesirable character was the free suckering habit.

THE METHOD USED.

Each variety was numbered and a cross between No. 1496 Cagayan and No. 973 Broadleaf is written (1496 × 973), the pistillate parent always coming first.

The crossing of two varieties was done by splitting the corolla before the flowers open, and removing the stamens. Pollen was gotten from another variety and was applied to the pistils of the flowers which had been emasculated. The flowers not used were removed, and the seed-head was then covered with a Manila paper bag. The bags were removed at the end of eight days, and by this time nearly all the capsules were formed.

(1) Number given by the writer.
(2) College number.

TYPE A.—CAGAYAN—BROADLEAF PLANT—"TIRONA" TOBACCO.

Photograph by Ledyard.

In crossing, it is very important to know when the flowers are ready to be pollinated, because immature flowers do not set fruit. One of the men who worked on the effects of premature pollination was Hartley and he obtained a higher percentage of successes than the writer. In this experiment, of flowers pollinated twelve hours before they open, 84% matured capsules; and of those flowers pollinated just before they open, 91% produced them. The method which gave a high percentage of success was emasculating the flowers in the evening and then bagging the seed-head. About ten o'clock in the morning, the bag was removed, the pistils pollinated, and then the bag replaced. The following are the statistics on pollination:

15 flowers pollinated twelve hours before opening.
12 pods were produced..... 80%.
18 flowers pollinated twelve hours before opening.
16 pods were produced..... 88%.
23 flowers pollinated when fully receptive.
21 pods were produced..... 91%.

RESULTS

The different crosses made are the following:

Cagayan × Connecticut Broadleaf or (1496 × 973), Cagayan × Connecticut Havana or (1496 × 974).

Enough capsules were produced from these crosses to furnish seed for the planting of the first generation of the hybrids. Planting began on September 9, 1913.

The following are the descriptions of the hybrids obtained from the different crosses:

CAGAYAN × BROADLEAF (1496 × 973).

Plants very vigorous, varying from 1.5–2.3 meters high; stem nearly straight, cylindrical, 5-11 centimeters in circumference. Leaves drooping to ascending, broad ovate-lanceolate, base auriculate-clasping, acuminate to blunt-acuminate at apex; 3.5 decimeters to one meter long; 2-5 (1) decimeters wide; 5-16 square decimeters in leaf area, and 17-30 in number. Flowers very numerous, in dense panicles, corolla salver-form, tube 6.5 centimeters; color light pink; stamens 5; anthers 4-5 millimeters long, 2 millimeters thick; pollen abundant; style 4-5 centimeters long; ovary 10 millimeters long, 5 millimeters wide; capsules numerous.

Out of the hybrids planted, nine plants were selected for future work. These selected plants are classified into three types, "A," "B," and "C" for convenience in keeping the records of the important features of the individuals.

"Type A" consisted of one plant which was the best and most vigorous of all. The height was 2.3 meters and the circumference of the stem was 11 centimeters, measured at 30 centimeters above the ground. This plant produced 22 leaves, excluding the four bottom leaves, and with a leaf area averaging about 12.5 square decimeters. This individual approached the desired type, because the outline was broad and the tip blunt.

"Type B" consisted of seven plants. The average height was two meters, and the circumference of the stem was 9.5 centimeters. This type produced an average of twenty-five broad, ovate-lanceolate leaves with a leaf area of eleven square decimeters.

"Type C" consisted of one plant, and it resembled "Type B" in its characters except that the leaves were more erect instead of drooping as in "Types A" and "B". This character is quite important because drooping leaves are

(1) The range is between the leaves of plants.

SELECTED CAGAYAN-BROADLEAF PLANTS.
(Tirona—Hybridization of Tobacco, page . . .)

greatly damaged when plants are cultivated, and also in time of rain the leaves rot very readily if they touch the soil before they mature.

These hybrids are wrapper type, which can produce four or five wrappers instead of two or three like their parents. The cured leaves were thin, elastic, and had a fine, light color.

CAGAYAN × HAVANA (1496 × 974)

Plants vigorous, varying from one to two meters high; stem 10.5 cm. in circumference. Leaves erect, broad-ovate-lanceolate; base slightly clasping, tips acuminate and slightly drooping; 5 to 7 decimeters long; 2 to 4 decimeters wide; 4 to 11 square decimeters in area; and with an average of 22 leaves.

Flowers in panicles, corolla salver-form, corolla tube 3.5 cm. long; spread of corolla lobes 2 to 3 cm.; color light pink; anthers 3 to 5 mm. long, 1 mm. thick; pollen abundant, style 2 to 3 cm. long, and ovary 0.7 cm. long.

Four plants were selected, and the average height was two meters with a circumference of 10.5 centimeters. The number of leaves averaged 22 and the leaf area was 11 square decimeters. This is also a wrapper type.

In both of these two crosses, Cagayan × Broadleaf and Cagayan × Havana, the morphological characters of the hybrids, such as height, size of stem, shape, habit, distribution and base of leaves, etc., were greatly influenced by the staminate parents.

SUMMARY

There are three hybrid strains isolated from the Cagayan × Broadleaf cross, and one from the Cagayan × Havana. All of them are good wrapper types, which produce twice as many wrappers as either parent had done here.

2. By the luxuriance of growth and adaptability to the local environment of these hybrid strains, is indicated the possibility of raising high class wrapper here.

3. Inbred seed selections in order to fix the types have been started from the best of all these strains for future breeding and selection work.

4. The physical characters of the staminate parents in the hybrids were dominant over those of the pistillate.

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"Type A" at the age of one month and nine days.

Typical leaf "Type A," leaf area
12.5 sq. dm.

The Efficiency of Leguminous Plants in Increasing the Nitrogen Content of the Soil

By Vicente Concepcion Bartolome

Thesis presented for graduation from the College of Agriculture No. 14.

The importance of leguminous plants as food for man and animals, and their value for maintaining and increasing the fertility of soils, make them worthy of extensive investigation. As a preliminary experiment a number of varieties were collected and planted on 10 by 20 meter plots for the purpose of determining the amount of nitrogen fixed in the soil independent of that removed by the crop; and to determine, if possible, the ones most suited to the improvement of worn-out soils. It is obvious that the results of one year's trial are not enough to justify conclusive statements, but it is hoped that they may prove useful in pointing out the fact that there is a difference in the value of the different species for this purpose.

As early as 1838, Boussingault[1] demonstrated that clover and peas differ from cereals in that the former have the power to increase the nitrogen content of soils in which they are grown under natural conditions. This fact was taken as ground for the belief that the legumes mentioned could fix atmospheric nitrogen by the aid of their foliage leaves.

Later experiments by Boussingault[2] were carried out with soil which had been heated to destroy the organic compounds contained in it. These researches gave negative results and led their author to change his former opinion, and regard the organic compounds of the soil as being the source of the nitrogen used in the growth of higher plants. We know today that the ignition intended to destroy the organic compounds of the soil served also to render it sterile, and prevented the fixation of nitrogen by bacteria.

It was noted by the investigators at Rothamstead[3] and other places that the amount of nitrogen accumulated by leguminous crops was much greater than that by other crops.

In another experiment[4] conducted at the same place a piece of land previously planted to beans was left to fallow for a period of five years and then sown to barley and clover, the latter being allowed to stand for two years. At the start the soil was analysed and found to contain 2657 pounds of nitrogen per acre to a depth of 9 inches. As a result of the cropping of barley and clover and then of clover alone, 3,195 pounds of nitrogen was removed, yet the soil contained on analysis at the end of the time specified 2,832 pounds of nitrogen per acre in the top 9 inches, or a gain of 175 pounds per acre, making a total, with that removed in the crop, of nearly 500 pounds of nitrogen per acre to be accounted for.

The result of these and similar experiments was that many observers were led to think that there might be some fixation of the free nitrogen of the air, in spite of the contrary opinion of Boussingault, Liebig and others. Voelcker when discussing the power of the clover plant to accumulate nitrogen expressed the opinion that the atmosphere furnishes nitrogenous food to the plant; in France, Ville expressed a similar view; while Berthelot brought evidence to show that the soil itself by the aid of microscopic vegetation assimilated free nitrogen. It was not, however, until the publication of the paper by Hellriegel and Wilfarth in 1886 that the subject was cleared up. They "found that when plants were grown in sand

1) Ann. de chem. et de phys. (2) *67*, (1838) 5–54.

2) Compt. rend. *38* (1854) 717; *39*, (1854) 601–603.

3) Hall. The Rothamstead Experiments. p. 9.

4) Hall. loc. cit. p. 10.

and fed with nutrient solutions, the Gramineae, the Cruciferae, the Chenopodiaceae, the Polygonaceae grew almost in proportion to the combined nitrogen supplied; and that if this were absent nitrogen starvation set in as soon as the nitrogen stored up in the seeds was exhausted. With the Leguminosae, however, a plant was sometimes observed to recover from the stage of nitrogen starvation and begin a luxuriant growth that lasted till maturity, though no combined nitrogen was supplied. In such cases the root of the plant was always found to be beset with little nodules characteristic of leguminous plants when growing under natural conditions. Further experiments were made in which the plants were grown in sterile sand, but as soon as the stage of nitrogen starvation was reached a small portion of water extract of ordinary cultivated soil was added; whereupon the plants receiving the extract recovered from their nitrogen starvation and grew to maturity, assimilating considerable quantities of nitrogen. The renewed growth and assimilation of nitrogen were always found to be attendant upon the production of nodules on the roots. The nodules were found to be full of bacteria to which the name Bacillus radicicola has been given. (1) "Moreover Schloesing *fils* and Laurent found that when plants were grown in closed vessels, there was an actual disappearance of the nitrogen gas agreeing with the amount gained by the plant during growth."

It has further been observed that leguminous plants benefit non-leguminous plants, not only when they are grown and plowed under to decay in the soil, but even while they are still growing, if they have been planted with the non-leguminous plants. This was shown by the New Jersey Experiment Station; "Non-leguminous plants such as corn and cereals grown in close association with legumes benefit in some manner by the nitrogen fixing ability of the legumes. This benefit is quite marked but the channel through which it is exerted has not yet been determined." [1]

This is probably due to the fact that the nodules after reaching full development begin to collapse and drop off carrying with them not only bacteria which are liberated for the infection of new roots, but also freeing nitrogen compounds which may be taken up by other crops.

AGRONOMICAL DATA

The land used in the present experiment is nearly level and is situated at the foot of a gentle slope. The soil is a rather heavy clay underlaid at the depth of about one meter with volcanic tuff more or less decomposed on top. This land had been previously cropped, first with legumes and then with rice and corn; so that the soil probably contained the proper bacteria when the experiment began.

The preparation of the land consisted of two plowings and harrowings. As previously stated the plots were laid out 10 by 20 meters, making them one fiftieth of a hectare each.

The varieties under observation were:

Plot No.	*Varieties used*	*Botanical names*	*Date of planting*
1	Peanuts...	Arachis hypogaea...	May 27, 1912
2	Sincamas..	Pachyrrhizus erosus.	" 28, 1912
9	Velvet bean	Mucuna Lyonii.....	June 3, 1912
13	Cow peas..	Vigna Catjang.....	" 4, 1912
16	Sinay bean.	Phaseolus calcaratus	" 5, 1912
17	Soja bean..	Glycine hispida.....	" 5, 1912
18	Ami's bean.	Glycine hispida var.	" 6, 1912

The weeding and cultivation of these plants began after their germination, and ceased when such operations became impractical on account of the growth of the plants.

Arachis hypogaea, variously known as peanut, mani, cacauate, and cacahuete, is an annual plant, a spreading, hairy, branched herb, the stems 30 to 80 cm. long. The leaves are from 8 to 12 cm. long, the base of the petiole clasping, the sheath produced in two

1) Hall. loc. cit. p. 11.

1) Year Book of the United States Dept. of Agriculture for 1910.

linear lanceolate stipules. The leaflets are oblong to obovate, 2 to 5 cm. long. The flowers are axillary, few—fascilled, yellow, about 8 mm. long, containing from 1 to 5 seeds. The plant, while widely distributed over the Islands, cannot be said to be extensively cultivated. Where grown it is fully as important as a forage plant as for its fruits or nuts. Where grown locally the land is prepared by plowing and harrowing once or twice, according to the previous condition of the land. It is then laid in furrows about one meter apart and the seeds dropped in the furrow at distances of about a meter; several seeds being dropped in a place to insure germination. This distance seems suited to the strong vining variety grown locally but would be too far apart for the variety used in this experiment. Cultivation may consist of one or two light plowings or weedings.

In the experiment here reported the plants were 45 cm. apart in rows, and the rows 90 cm. apart.

Pachyrrhizus erosus (L) Urb., known by the Tagalogs, Visayans and Bicolanos as sincamas, is a rather coarse, scandent, herbaceous vine, somewhat pubescent, forming rather large, edible, turnip-shaped, fleshy roots. Leaflets, at least the terminal one, broader than long, up to 15 cm. long and 20 cm. wide, base deltoid, irregularly and shallowly lobed in the upper half, the lateral ones inequilateral. Racemes up to 45 cm. in length, the lower nodes produced into short branches, each node with several flowers. Flowers pale-blue, 2 to 2-5 cm. long, the standard about 1.5 cm. wide. The pods about 10 cm. long, 10 to 12 mm. wide, flat, pubescent, containing 5 to 8 seeds.

This plant is not very extensively cultivated. The seed is sown at the close of the rainy season, for if planted during the wet season it will run to vine and produce inferior tubers. The plant as planted locally is sown in rows 75 cm. apart, spaced 15 cm. in the rows. The cultivation is the same as that of the peanut. In the experiment carried on, the plants were 15 cm. apart and the rows 90 cm.

Mucuna Lyonii Merr. (known as velvet bean by the Americans, garabansong tagalog by the Tagalogs, and calabantos by the Visayans) is a short, herbaceous vine reaching a length of four meters or more. The leaflets are thin, broadly ovate, the lateral ones oblique, 5 to 18 cm. long, slightly hairy beneath. Racemes up to 40 cm. in length. Flowers numerous, about 4 cm. long, the calyx grayish pubescent, the corolla dark-purple. Pods 6 to 10 cm. long, 1.5 to 1.8 cm. wide, the valves with two longitudinal ribs, rather velvety pubescent, with short gray hairs but no stinging hairs.

Vigna Catjang, (cow peas), known variously as ayap, paayap and quibal in Tagalog, hamtac and laston in Visayan), is an annual bean-like rambling vine with three rhomboid-ovate, stalked leaflets, the lateral ones unequal-sided, the petioles long. The flowers are bean-like, white, 2 or 3 together on the summit of a long axillary peduncle. The pods are slender. The seeds are small, kidney shaped, bean-like, and white. The plant, while widely distributed over the Islands, cannot be said to be extensively cultivated. The pods are generally sold when not full grown, in bundles about the size of a man's wrist for 2 centavos each.

Phaseolus calcaratus Roxb, known as sinay, is slender, herbaceous, nearly glabrous, or somewhat pubescent, the stipules peltate. Leaflets ovate to oblong-ovate, acute or acuminate, entire and shallowly lobed ones commonly found on the same plant, 5 to 10 cm. long. Racemes long-peduncled, flowers few

at the apex, yellow, about 1.5 cm. long. Pods slender, slightly appressed, hairy or glabrous, 6 to 10 cm. long, about 5 mm. wide, the valves twisted when dry.

Glycine hispida, variously known in English as Soja bean, coffee and coffee berry, is one of the beans lately introduced. What is called Ami's bean in the records of this college is a variety of the soja bean. It is unknown to local farmers.

Since the outcome of the experiment must have been more or less dependent upon climatic conditions, a table of rainfall and maximum and minimum temperatures will be given. There was no heavy rainfall during the experiment, and the temperature was within the range of those known to be most favorable for bacterial action in general.

RAINFALL RECORD. 1)

1) Compiled from College of Agriculture Weather Records.

Months	*Total Rainfall*	*Maximum Daily Rainfall*
June	81.2 mm.	20.5....on June 1.
July	295.0 mm.	45.9....on July 18.
August	460.0 mm.	123.0....on August 31.
Sept.	318.4 mm.	116.8....on September 1.
October	400.9 mm.	93.1....on Oct. 17.

TEMPERATURE RECORD

Months	*Maximum Temperature*	*Minimum Temperature*
June	33.0 C	22.4 C
July	31.5 C	22.3 C
August	30.8 C	22.2 C
September	30.6 C	21.7 C
October	31.0 C	22.2 C

The kind of crop grown in each of the fields and the date of planting and harvesting is shown in the table below.

No.	*Crop*	*Date planted*	*Plowed under*
1.	Peanuts	May 24, '12	Oct. 1, '121
	"	Dec. 25, '12	May 17, '13
2.	Sincamas	May 24, '12	Oct. 1, '12
	"	Dec. 25, '12	May 17, '13
9.	Velvet bean	May 24, '12	Oct. 11, '12
	"	Dec. 25, '12	May 17, '13
13.	Cow peas	May 24, '12	Oct 1, '12
	"	Dec. 25, '12	May 17, '13
16.	Sinay	May 24, '12	Oct 1, '12
	"		May 17, '13
17	Soja	May 24, '12	Oct. 1, '12
	"		May 17, '13
18.	Ami's	May 24, '12	Oct. 1, '12
	"		May 17, '13

Fields 1, 2, 9 and 13 grew two crops and the others only one. In the plowing under the first crop the seeds were harvested, but with the second crop the whole plant was plowed under.

I found 30 pesos for total cost of cultivation, weeding and other care given to plants from the following data:

A man and a carabao can be hired for 2 pesos a day. He can plow and harrow in one day about 1,000 square meters or 1-10 of a hectare. Therefore one hectare could be plowed and harrowed in ten days or an equivalent of 20 pesos. The cultivation, which is done by light plowing, and other care given to crop I assume to cost about 10 pesos.

III.—CHEMICAL ANALYSES

The chemical analyses of the soil were made after the crop plowed under had been allowed to rot for four weeks, and once more plowed before taking the soil samples.

The loose upper soil was first leveled and then the soil sample was removed to a depth of 10 cm. with an auger. Samples were taken from ten different places in each plot on the following days: Plots numbers 1 and 2 on June 12th. Plots numbers 9, 13, 16, 17 and 18 on June 14th. These soil samples were air dried for several days, sifted through a wire gauze of one mm. mesh, and preserved in glass-stoppered bottles.

Recent experimenters have claimed that a portion of the nitrogen in soils is not easily obtained by the ordinary digestion with sulphuric acid according to the Kjeldahl method. Various catalyzers have been proposed for the purpose of aiding the decomposition and oxidation. One of the most successful of these is reported to be a mixture

of copper sulphate and ferrous sulphate. In order to determine the effect of varying the kind of oxygen carrier and time of digestion, the following preliminary experiment was undertaken.

Wgt. of soil moisture 6.2%	*Time of digestion*	*Catalyzer*	*NaOH[1] cc. Experiment*	*NaOH cc. control*	*Per cent. N (Oven dried)*
9.162g.	5 hrs.	2g $CuSO_4$ 5g $FeSO_4$	33.61	36.65	0.131
9.475g.	5 "	" " "	33.56	36.65	0.128
				Av.	0.1295
9.554g.	5 "	Salicylic and Zinc	33.49	36.62	0.1290
9.645g.	5 "	" " "	33.46	36.62	0.129
				Av.	0.129
9.306g.	4 "	Trace $CuSO_4$; finished with $KMnO_4$	33.50	36.62	0.132
9.499g.	4 "	" " "	33.50	36.62	0.129
				Av.	0.1315
9.253g.	10 "	Trace $CuSO_4$	33.56	36.62	0.130
9.150g.	10 "	" " "	33.61	36.62	0.130
				Av.	0.130

(1) The sodium hydroxide used was 1.3184 N/5.

Forty cubic centimeters of concentrated sulphuric acid and fifteen grams of potassium sulphate were used in each of the above determinations. The variation between the results obtained with and without the use of copper sulphate and ferrous sulphate appears to be smaller than occasional differences between duplicates by the same method. A lengthening of the time of digestion to ten hours gave no increase of nitrogen that could be detected with certainty. Potassium permanganate seems to be unnecessary, and its use has been objected to by several observers on account of its liability to cause loss of ammonia by oxidation. Accordingly the nitrogen determinations to be given later were all made by digesting the soil for five hours with sulphuric acid and potassium sulphate containing only a trace of copper sulphate. It was found by actual trial that all of the ammonia contained in the digestion mixture could be obtained by distilling off 200 cc. after the addition of 300 cc. of distilled water and 100 cc. concentrated sodium hydroxide.

In the moisture determinations, the soil was dried at 110 C° to constant weight:

Soil No.	*Per cent. moisture in soil before crop.*	*Per cent. moisture in soil after crop.*
1.	6.00%	6.15%
2.	6.20%	6.28%
9.	6.47%	6.43%
13.	6.32%	6.39%
16.	6.42%	6.22%
17.	6.42%	6.28%
18.	6.35%	6.11%

In these analyses the control required 43.9 cc. of N5 alkali, and the soils after legumes had grown on them, about 40.7 cc. Therefore the difference between the amount of alkali used in the control and that used in the soil analysis was in each case about 3.2 cc. But since the actual error in determining the end point by the use of methyl orange is at least three one-hundredths of a cubic centimeter, it is probable that the accuracy of the analyses made cannot be relied on within one part in one hundred. In fact the difference between duplicate results is frequently somewhat larger than this. Calculations of the per cent of nitrogen in the soil and of the profit coming from the growth of the legumes will accordingly not be carried out with greater accuracy than that mentioned.

No.	*% of N before planting (oven dried soil)*	*% of N after planting (oven dried soil)*	*Difference gain or loss*	*Gain in Kgs. per Ha. (Surface soil 10cm)*
1.	0.110	0.114		
	0.112	0.110		
Average.	0.111	0.112	+0.001	+10
2.	0.120	0.133		
	0.122	lost		
Average.	0.121	0.133	+0.012	+140
9.	0.124	0.123		
	0.126	0.123		
Average.	0.125	0.123	—0.002	—20
13.	0.120	0.123		
	0.116	0.125		
Average.	0.118	0.124	+0.006	+70
16.	0.121	0.128		
	0.127	0.132		
Average.	0.124	0.130	+0.006	+70
17.	0.125	0.122		
	0.125	0.114		
Average.	0.125	0.118	—0.007	—80
18.	0.124	0.125		
	0.120	0.124		
Average.	0.122	0.124	+0.002	+20

The calculation of the weight of nitrogen gained per hectare was based on the apparent specific gravity of soil in its natural state of compactness. This was determined by removing a prism of firm soil from the field, measuring it carefully, and drying to constant weight at 110 degrees. The result obtained for the apparent specific gravity of the dried soil was 1.16.

The gain in pesos was based upon the local market price of sodium nitrate containing 15% of nitrogen, namely P 1.06 per kilo.

Field No.	*Crop*	*Increase of N in surface soil*	*Value of N gained*	*Cost of labor*	*Net Profit*
		Kilograms	₱	₱	₱
1.	Peanut	+ 10	10	50	— 40
2.	Sincamas	+140	148	50	+ 98
9.	Velvet bean.†	— 20	21	50	— 71
13.	Cow peas	+ 70	74	50	+ 24
16.	Sinay††	+ 70	74	30	+ 44
17.	Soja	— 80	84	30	—114
18.	Amis	+ 20	21	30	— 9

For the sake of comparison a table may be given here, showing results obtained by other observers.[1]

Observer	*Kilos nitrogen gained per hectare per year.*— *Beans.*	*Peas.*	*Red Clover.*	*Lupines yellow.*	*Ornithopus sativa.*
Sestini	320		133		
Ch.Wood	228	219	167		
Dehlinger†			127		
Bassler, min.	158	80	137		136
Bassler, max.†	234		270		27
Schultz-Lupitz		223	143		
Schneidewind, max			226		229

SUMMARY

Sincamas gave a net profit of ₱98, Sinay and Cow peas ₱44 and ₱24 per hectare respectively. Velvet bean gave a loss of as much as ₱71, Soja ₱114, Ami's bean ₱9 and Peanut ₱40. However, velvet bean and Soja did not grow half as much as they ought to, probably due to lack of proper bacteria in the soil or to untimely planting. The peanuts were attacked by a fungous disease.

From the standpoint of nitrogen increase in the soil sincamas ranks first, sinay and cow peas second and third, and amis fourth.

We may conclude that, sincamas, either from the stand point of money return or nitrogen increase in the soil, ranks high, while cow peas and sinay, though they gave a return of nitrogen, could not be profitably cultivated for this purpose at the present cost of labor.

As for the rest of the plants, which gave a slight gain of nitrogen (Ami's bean and peanut), or gave a loss (Soja and Velvet bean) I call attention to the facts that seeds were harvested, and that the growth of these plants was not what it might be expected to be, for the reasons given above.

The writer's grateful acknowledgement and thanks are extended to Professors Baker and Cuzner, from whom he received valuable suggestions and much encouragement in the agronomical part; and to Dr. Deming for suggestions in carrying out the nitrogen determinations and help in reviewing the literature.

1) Lohnis. Handbuch der Landwirtschaftliche Bakteriologie. Berlin, 1910, p. 667.

Improvement of the Papaya

C. F. Baker

Professor of Agronomy, University of the Philippines

The papaya having become a fruit of recognized value, and one with a great future before it, steps are being taken to improve it in various ways. It possesses numerous fine varieties, some fruits exceeding a foot in length and several pounds in weight. It responds very readily to seed selection and to cultivation. At this date (Sept. 20), we have on the Agricultural College grounds trees just a year from seed, some of which already bear forty or more very large fruits, and numerous smaller ones coming on. These fruits would bring thirty centavos each on the Manila market as fast as mature.

The greatest fault of this fine fruit lies in its large percentage of fruitless male trees, which frequently amount to forty per cent or more of the entire planting. This problem has been attacked from various sides. From the United States Department of Agriculture we have notes on experiments in grafting over the males with female scions. Mr. Higgins, in Hawaii, has bred a race possessing monoecious flowers—males and females on the same tree. On my way to the Philippines I obtained seed of this form through the kindness of Mr. Higgins, and planted them immediately on arrival here. In one year they are loaded with fine fruit. The seed came from a pure monoecious parent. The progeny, as they occur in our planting, are most interesting. Of forty-five trees, 16 came pure males, 17 pure females, 2 monoecious, 7 possessed perfect flowers, while 2 were perfect and monoecious also. Here is a distinct advance over the monoecious type. We have inbred the monoecious and the perfect flowered forms, and also crossbred them, and will at once start extensive cultures for selection and breeding work. Among these trees are some wide variants in other respects, several having two to four fruits on a branched peduncle—an undesirable character—and others varying in the form of the fruit, though all fruits are large, heavy, and fine eating.

In the meanwhile a separated culture of the Dapitan papaya from Zamboanga (selected seed obtained by Dr. Copeland), has given results almost as interesting as those of the Hawaiian form. The best Dapitan is a finer papaya than we have been able to get from Hawaiian seed. Of 38 trees, 7 came pure males, 12 pure females, 17 monoecious, and 2 perfect as well as monoecious. It seems to me that great possibilities are wrapped up in those results.

Extension Bulletin No. 41 of the Department of Agriculture, University of Minnesota, is an exceptionally clear and concise statement concerning concrete silos. The estimated costs are probably lower than could be realized in the Philippines. The directions are clear and are amply illustrated with photographs and diagrams so that any competent mechanic could proceed to build a silo, either monolithic or of concrete blocks. There are also tables showing the capacity of silos of various sizes, and also showing the size of silo needed to supply herds of different size for given periods. The whole bulletin includes only fourteen pages; all interested in silos should secure and read it.

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EDITORIAL

THE PHILIPPINE AGRICULTURIST AND FORESTER has been compelled to give up the attempt to publish at a rate which would justify it in claiming credit for continuous publication. We have hoped for the past year and a half that it would be possible, by printing two to four numbers at a time, to present enough material to represent a volume each for 1912 and 1913. As far as amount of material for publication goes, we could probably have done this; but the cost of publication is so great that, without some return from advertisements in each issue, we are unable to get the volumes out. The alternatives are therefore to suspend publication permanently, or to take a fresh start: The favorable reception which our magazine enjoyed during its first year, encourages us to choose the latter. We therefore begin with this issue Volume III, to consist of ten numbers, to appear during the year 1914. There will be no volume for 1913, and volume II for 1912 will not be completed. Subscribers outside of the college, who have paid for Volume II, will have the value of the four numbers which did not appear applied to the volume which now begins. An index to Volume I and to Volume II, as far as published, will be mailed in the near future.

From the material in hand for publication, and the satisfactory business arrangements which we have been fortunate enough to make, we feel safe in promising to subscribers prompt and regular publication for the future.

The project of a college of tropical agriculture to be established in some British colony, and to be, at least in a sense, an imperial institution, is receiving a great deal of attention in England and in tropical British colonies. Such an institution would be so useful that one can hardly doubt that the agitation will result in its establishment. The foremost candidates as places for its establishment are Jamaica and Ceylon. The planters of Ceylon have given that island an enviable .place in the agriculture of the Old World tropics. A proposed site has wisely been reserved in connection with the Botanic Garden at Peradeniya, where the institution will begin its work more advantageously than would probably be possible in any other British colony.

The advocates of the scheme are maintaining that this will be the first college of tropical agriculture. The claim is amusing here since agriculture in the Philippines seems to be tropical, and there is no evidence to date that the proposed college will have as complete a course or as many students as the College of Agriculture of the University of the Philippines. The tentative plans, however, provide for an investment in buildings of at least five times the sum which has been used for this purpose here. The general building scheme is modeled after that of the College of Agriculture at Cornell University. It is proposed that accommodations be made for seventy students at the opening of the college.

Good luck to the scheme. We will be very glad to have another college in the field, and to have it be a neighbor in the Old World.

The Value of Ipil-Ipil as a Soil Renovator

By Antonio Lemon Lejano

Thesis presented for graduation from the College of Agriculture, No. 13

The Ipil-ipil (*Leucaena glauca*) or Santa Helena is a tree which thrives so abundantly all over the Philippines that it is generally regarded by the farmers as a weed. It grows at the boundaries of fields, and in all sorts of exposed areas, and if not watched will soon be found growing in plowed fields planted to other crops. It will be found growing here and there side by side with the Madre Cacao and usually more abundantly than the latter.

The foresters find it the most efficient plant to fight against the cogon. It is quick growing, and therefore soon shades the cogon (lalang, *Imperata*) and kills the latter out. The foresters in their experimental plots find that it takes from 10 to 20 days to germinate, with from 40 to 50 percent germination. Data as to the value of Ipil-ipil for wood have been kindly furnished me by Mr. Oteyza, based upon the results obtained from their experimental plots, where a part of my work has been carried out. He says that the yield per year per hectare is about twenty-two cords stack (not solid). This is sold in town (Los Baños) at five pesos per cord, the value in money being ₱110.00 per year for one hectare of ground. But some expenses are involved. The cost of hauling to town per cord is ₱1.00, for cutting ₱1.00, forest tax ₱0.50, the total expenses being ₱2.50 or one half of the total value of the wood. This makes then a total net profit of ₱55.00 per year for one hectare. The diameter of the trunk that is cut varies from 0.75 cm. to 3.5 cm.; the height being 4 m. The fuel value of Ipil-ipil is second to Madre Cacao, which is considered as first class for fuel. The chief quality of the wood for fuel is its straight grain, which makes the wood easy to split. A kilogram of seeds (cleaned) costs ten centavos. Mr. Oteyza further comments that it is the most practical crop for badly exposed areas. Beside for wood, the foresters plant Ipil-ipil for two other purposes. First, to get rid of the cogon and second, to provide shelter for the seedlings of other forest trees. The seedlings of forest trees find a place to grow under the Ipil-ipil, and when large enough the Ipil-ipil is cut and can be used for fuel.

Then a third purpose for which the Ipil-ipil serves, which is probably of greater interest to agriculturists than to the foresters and which has not been investigated, is its value for adding nitrogen to the soil. Leguminous trees are used to shade coffee, cacao, and other important crops, and we may assume that nitrogen is being added to the soil by these legumes which in turn will be taken up by the crop, but no work to determine the real value of our leguminous trees for this purpose has yet been undertaken. My work has had two aims: First, to find how much nitrogen the nodules contain, and second, to find the total gain of nitrogen by comparing the nitrogen content of soils with and without Ipil-ipil.

For the latter purpose the experiment has been conducted in 8 places (four Ipil-ipil patches and four cogon fields adjacent to them respectively) for fear that if the work should be conducted in two places only, the difference in composition of the two soils, which will be taken to represent the total gain of nitrogen due to Ipil-ipil,

would be due to the differences in composition before the Ipil-ipil was planted. In the four patches of Ipil-ipil where samples for analysis have been taken nodule formation has also been studied.

The following facts have been observed:

1. That the nodules are developed on the filamentous feeding roots.

2. The nodules are lateral, that is, they do not interfere with the growth of the roots.

3. Large roots do not have nodules.

4. The Ipil-ipil has numerous spreading roots bearing nodules near or at the surface. Some of the large, branched nodules can be seen at the surface, protruding like small tubers.

5. Within a depth of from 0 to 5 cm. they are generally abundant but at 12 cm. they can hardly be found. Those found deeper are scarcely branched and some of them are compressed, especially when the soil is hard. Most nodules found at the surface are branched.

6. Nodules are of various shapes. The small ones are generally found, next in size come the oval ones, then those that are elliptical, others are elliptical but more elongated, then lastly we find those that are curiously branched in various ways.

Table I

Weights of nodules in grams per 30 cm. square in four fields.

		I	*III*	*V*	*VII*
1.	Fresh	11.25	7.13	9.22	11.22
	Dead	0.99	0.89	0.75	1.00
2.	Fresh	7.95	8.21	9.44	8.06
	Dead	0.53	0.56	2.00	0.85
3.	Fresh	11.46	5.82	8.78	3.04
	Dead	1.21	1.05	0.52	0.65
4.	Fresh	10.26	6.13	7.12	12.22
	Dead	1.32	0.49	0.54	0.55
5.	Fresh	6.33	6.09	7.02	12.03
	Dead	0.98	1.31	1.82	2.01
6.	Fresh	6.33	6.99	6.92	8.24
	Dead	1.25	0.64	0.92	1.23
7.	Fresh	8.22	9.20	5.12	7.55
	Dead	1.13	1.56	0.70	0.82
8.	Fresh	13.92	7.24	7.00	4.92
	Dead	0.89	0.85	0.95	0.64
9.	Fresh	15.12	8.00	8.21	8.24
	Dead	2.10	0.91	1.01	1.12
10.	Fresh	9.37	7.25	6.83	10.40
	Dead	1.20	0.75	0.75	0.72
Av.	Fresh	10.60	7.20	7.07	8.40
	Dead	1.16	0.70	0.99	0.96

Table 2

Analyses of nodules.

	Percent Water	*Av.*	*Percent Nitrogen*	*Av.*
Fresh Nodules....	79.5 79.7	79.6	0.883 0.881	0.882
Dead Nodules....	32.01 32.04	32.02	0.731 0.732	0.731

Note: Moisture determined by drying at 110° C.

Table 3

Weights of nodules in table I calculated per hectare, kilos of nitrogen that can be obtained therefrom and their value estimated (per hectare also).

		Kilos of Nodules	*Kilos of Nitrogen.*	*N @ ₱.74 per kilo.*		*N @ ₱1.06 per kilo.*	
I	Fresh	1178	10.4	7.60	Total	10.90	Total
	Dead	129	0.9	0.70	8.30	0.90	11.80
III	Fresh	799	7.0	5.20	5.60	7.40	7.90
	Dead	77	0.5	0.40		0.50	
V	Fresh	785	6.9	5.10	5.70	7.30	8.10
	Dead	109	0.8	0.60		0.80	
VII	Fresh	932	8.2	6.00	6.50	8.70	9.40
	Dead	106	0.7	0.50		0.70	
Average					₱6.50		₱9.30

The figures in Table I are the weights of nodules in the four fields Nos. I, III, V, and VII in ten different places in each field. The area dug in each place was 30 cm. square (900 sq. cm.) as deep as any nodules could be found. But beyond 12 centimeters deep no nodules could be found, and after this fact was observed the digging was not carried very far beyond 12 centimeters.

Knowing the weight of nodules per hectare and the percent of nitrogen in them, the kilos of nitrogen can then be calculated, and thus the value of these nodules when the price of nitrogen is known. Nitrogen at ₱0.74 a kilo is the price in the United States, where nitrate of soda containing 15.5% costs $52.00 or ₱104.00 per ton. In the Philippines, where the commercial fertilizers are sold at a higher price, a kilo of nitrogen is worth ₱1.06. As can be seen from Table I, the production of nodules per year in the older fields, III, V, and VII (which have

been growing for three years) is slightly less than the production in Field I, which has been growing for 1.7 years only. The average market value of the nitrogen in the nodules for the four fields studied is ₱6.50 per hectare in the United States, or ₱9.30 in the Philippines. If the rate of production can be determined, then the total output per year can be calculated, and consequently the total value of nodules per year. In the last part of my work, however, where nitrogen content of soils is determined, this has been indirectly solved. The figures in Table II are the analyses of nodules (fresh and dead) and the determination of their moisture by drying in an oven at 110° C to constant weight. A qualitative test for nitrates was made, but none was detected either in the dead or living nodules, so that the ordinary Kjeldahl method was used. To aid in oxidation, copper sulphate was used instead of potassium permanganate. The time allowed for digestion was more than five hours. The indicator used for titrating the standard acid left over after the distillation was methyl orange, care being taken to use the least amount that can be conveniently detected by the eye.

The following are the analyses of soils I, III, V, and VII (with Ipil-ipil) and the adjacent cogon soils II, IV, VI and VIII.

Table IV

	Per Cent Nitrogen			Per Hectare					
	Air Dried	Oven Dried	Aver. Oven Dried	Diff. of N. %	Kilos of N. Gain	N @ ₱.74 per kilo Pesos	N @ ₱.74 per kilo Pesos per yr.	N @ ₱1.06 per kilo Pesos	N @ ₱1.06 per kilo Pesos per yr.
	0.0886	0.0945							
Soil I....			0.0944						
	0.0884	0.0943							
	.....	.....	.....	0.0075	104	77	45.30	110.20	64.80
	0.0820	0.0874							
Soil II...			0.0869						
	0.0810	0.0864							
	0.1224	0.1306							
Soil III...			0.1308						
	0.1228	0.1309							
	.....	.....	.....	0.0114	158	117	39.00	167	55.60
	0.1110	0.1184							
Soil IV...	0.1130	0.1205	0.1194						
	0.1343	0.1432							
Soil V....			0.1434						
	0.1345	0.1435							
	.....	.....	.....	0.0104	144	107	35.60	153	51.00
	0.1247	0.1334							
Soil VI...			0.1330						
	0.1243	0.1326							
	0.1373	0.1465							
Soil VII..			0.1464						
	0.1371	0.1463							
	.....	.....	.....	0.0103	143	106	35.30	152	50.60
	0.1271	0.1356							
Sail VII..			0.1359						
	0.1277	0.1362							
Average ..							38.80		55.50

Note:—Sample taken 12 centimeters deep.

In the analyses of soils (Table IV), the same procedure was followed as in the analyses of nodules. The digestion in this case required more time, not less than five hours. As in the analysis of nodules potassium sulphate was used—about one tea-spoonful to each sample.

The figures obtained by Mr. Bartolome for the percentage of moisture in air-dried soils were used in the recalculation of the analyses to the oven-dried basis, the average of his figures being 6.28% moisture.

Samples of soil were taken at eight places in the field; every precaution was taken to make the sample a real representative of the soil in the field. Details of sampling are similar to those described in most texts. The weight of dry soil per hectare was calculated by determining the weight of oven-dried soil in a space in the field 20 × 20 centimeters and 12 centimeters deep. The apparent specific gravity taken in this way turned out to be 1.16. This is 1390 metric tons of oven dried soil per hektare.

The duplicate analyses (Table IV, second column) generally differ by about six units in the fourth place of decimals. Where the average percentage composition of my soils is 1161, the possible error would be about six parts in 1100 or about ½%. This means that the errors in analysis affect the total gain by ½%. We must consider the possibility of other sources of error, viz. in assuming that the compactness of the soil in the field is the same throughout as in the spot dug for sample to determine the apparent specific gravity of the soil. The profit due to increase of nitrogen is accordingly calculated only to the nearest peso.

The total gain in nitrogen per year (see Table IV) in field I, which is 1.7 years old, is somewhat greater than that in either one of the other three fields, which are three years old, seeming to indicate that the rate of nitrogen production becomes less as the trees get older, but no safe conclusion can yet be drawn from this experiment on this particular point. The average total gain of nitrogen in the four fields is ₱38.80 per year per hectare when nitrogen is sold at ₱0.74 a kilo, or ₱55.50 at the local price of ₱1.06 per kilo.

Summary and Conclusion

The value of Ipil-ipil for wood is ₱55.00 per year per hectare (result obtained by the foresters). The value of nodules per hectare at one time is ₱6.50 at prices in the United States, or ₱9.30 at prices in the Philippines. If the rate of production of nodules can be determined in a given area, the total output and consequently the total value of these nodules per hectare can be ascertained. The total gain of nitrogen by the soil growing ipil-ipil is worth ₱38.80 a year per hectare (average for four fields) when a kilo of nitrogen is sold at ₱0.74 per kilo, or ₱55.50 at the local price of ₱1.06 per kilo. From the results obtained it is safe to conclude that Ipil-ipil is a good soil renovator, that its value in adding nitrogen to the soil is about equal to its value for wood production. Since roots and tops both pay there is no reason why it should not be used as a shade tree for coffee, cacao and other delicate plants if it proves locally practical. And since Ipil-ipil is a money paying crop and costs practically nothing to plant, it should be planted on soils now left uncultivated, instead of allowing cogon and other weeds to thrive.

I am under obligation to Professor C. F. Baker for his valuable help in the preparation of this thesis, to Professor E. B. Copeland and Professor H.G. Deming for their suggestions and criticisms during the progress of this work, and to Mr. M. J. Oteyza for his generosity in furnishing me some data.

Introduction of Plants in Tropical Countries

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One of the most spectacular features in the Agriculture of the last century was the transplantation from great distances and sudden change from scattered and wild condition, to fine and immensely valuable cultivated plantations, of Cinchona (Quinine), Hevea (Para Rubber), and other important plants. Cinchona was snatched out of the wilds of Peru, and Hevea taken from the valley of the Amazon, to add to the riches of Ceylon, Java, and the Malay countries. The credit for this great work belongs to Englishmen, and in part to the Kew Gardens. Indeed of all agencies, the English Botanic Gardens have perhaps exercised the greatest leavening influence on the tropical agriculture of the world. Such names as Willis, Fawcett, Ridley, and Wright, are names to conjure with in connection with the subject of tropical agronomy. The most extensive work in the originating and disseminating of new canes, of experimentation with cacao and tea, and the introduction into English colonies of numerous valuable minor crops, are all due to the same enterprising sources. The story of these efforts and their results read in the existing assets of today, sounds like a fairy tale, the first introductions involving hazardous long-distance sendings of a few living plants—pioneers destined to found great industries in faraway lands. The stories of discoveries of gold fields in remote corners of the earth, by chance surface indications, can offer nothing more romantic or of greater moment to the world.

Very characteristic of early tropical agriculture was the extreme localization of crops. There was only one circumscribed region for good tobacco, another for spices, another for rubber, another for coffee, another for cacao, whereas, as has since been so conclusively proven, there are numerous other regions equally well adapted to producing these crops. A broadcast dissemination of the more important tropical crops was one of the great agricultural features of the last century. In later years an even more interesting development has been taking place—the gradual adaptation and modification of certain tropical plants to suit greater extremes of climate, the crowding of them farther and farther into the borders of the temperate regions, close up against or over the frost line, where greater margins of profit may often be realized from them than in their native climes.

While no other tropical cultures may ever exceed in extent those of rice, cane, corn, tobacco, coconut, coffee, tea, and cacao, it is well recognized that great numbers of as yet little known tropical plants are gradually coming into profitable culture. Numerous important tropical products are yet harvested only from wild plants. The masses of people of the temperate regions are developing tastes, uses, and needs for numerous tropical products formerly little known and practically unexploited. The market for tropical ornamentals in temperate regions, and even in parts of the tropics, has grown enormously in the past few years. With most of these things, extreme localization is again the rule. One mountain, one valley, one island, or one limited district, may possess plants sought by the whole world. Some of the finest things long in horticulture are extraordinarily local in their original distribution. Every exploration of new or little known regions furnishes a host of new horticultural and agricultural possibilities to the "prophetic eye." Some such regions have yielded full fledged horticultural and agricultural prizes equalling or even bettering some of our most highly improved economics of long standing, as for example, fine sugar cane out of Papua, and pomeloes out of South China and Siam. Novelties of great promise still appear in ever increasing numbers. Native and practically wild fruits of far greater promise than were the progenitors of any of our temperate region fruits,

occur in great numbers throughout the tropics of the world. Magnificent ornamentals in great variety are still unknown to horticulture. What a field for exploration, investigation, and future experimentation it all presents! The gardens so common about dwellings throughout the tropics, are notoriously poor in variety of ornamentals. One gets thoroughly tired of seeing all these little gardens planted with the same old pantropical ornamentals like Hibiscus rosa-sinensis, Caesalpinia pulcherrima, the Codiaeums, Dracaenas, and Aralias. One gets a very different impression when he visits a great tropical Botanic Gardens—say at Singapore—and sees grand and marvellous ornamentals, which are all the more noteworthy because not found widely distributed. Once seeing them, collectors or dealers would gladly pay almost anything within reason to obtain them. Wonderful scandent climbers like Hosea lobbiana, Bignonia magnifica, Clerodendron Thomsonae, and Camoensia maxima (a legume with colossal flowers 9-12 inches long). It is incomprehensible why a shrub with such magnificent flowers as has Randia Stanleyana, or a vine so incomparably beautiful as Beaumontia, should not have been more widely distributed —their culture is not difficult. Even the Philippines are rich in superb native ornamentals of the highest possible order of excellence, that are not only absolutely unknown to horticulture, but only very recently made known to science. Paramigyna longepedunculata is a splendid rutaceous vine provided with masses of rich cream-colored, orange-scented flowers. Derris philippinensis is a vine producing a display only exceeded in beauty and richness by the wistarias of Japan. Other woody vines of extraordinary beauty of flower or foliage are furnished by the genera Symphorema, Strongylodon, and Bauhinia. Few ornamental trees grown, exceed in beauty Milletia Foxworthyi, Wormia luzonensis, and Petraeovitex (fide Dr. Foxworthy).

When one passes to the fruits it may be said that many of the finest known to the tropics have never been in anything like cultivation—some not even in a state of semi-domestication. The mangosteen and durian of the East, and the biriba and cupuassu of the Amazon, are perhaps the regal fruits of the tropics—all exceedingly local in distribution. A promising new fruit now comes from the long settled Island of Mindanao, in Mangifera verticillata. But these are merely examples. Resident horticulturists in many parts of the tropics tell the same story of their own regions. Some of the richest and most interesting portions of the tropics are still almost wholly untapped, so fas as horticultural possibilities go. The larger Malayan islands, Central Africa, and the interior Amazonian region, are rich beyond the wildest dreams of temperate region horticulturists. The really curious thing is, that no concerted or systematic effort is being made to exploit all these riches. Their discovery and introduction is usually due to the individual enterprise and effort of some devoted enthusiast, and so the work proceeds at snail's pace.

The above discussion refers principally to distinct species of plants yet to be brought into horticulture. No less interesting, and of far greater immediate moment is the matter of rare and local varieties of species long known and cultivated. Reference has been made to the finding of a new and superb sugar cane in Papua. Not many years ago but few coffees were known, whereas now many are being tried out, some of

greater resistance to the destructive rust, than any formerly known. Certain varieties of cacao will thrive under conditions that others will not tolerate. New forms of Cinchona are replacing those first planted. Vast numbers of distinct varieties of bananas are known in the tropics—very many of the best confined to certain remote localities. No comprehensive work on banana culture has ever been attempted, though bananas are a tropical staple, the work never having progressed beyond local collections. The same is true of upland rices, of sweet potatoes, of yams, of legumes, and many other crops.

The fruits of the tropics, as well as cacao, rubber, and other important trees and shrubs, have been propagated almost wholly from seed. This has produced a most extraordinary and interesting condition from the horticultural point of view. It out-Burbanks in richness of opportunity anything even Burbank ever dreamed of. For instance, in the Philippines, one of our common fruits, the lanson, varies widely in character and value, as also the sapodillo (chico), the santol, and other fruits. Frequently trees are found giving fruit of exceptional size, flavor, or of exceptional yield. Some are found habitually fruiting off season, and hence of exceptional value. Absolutely nothing comprehensive has ever been done to seek and isolate these better forms, propagate them, and disseminate them. The mamey of the West Indies (Mammea americana) is sometimes described as a fruit of only medium size, hard and with large seeds, and the flesh resembling that of the carrot. But specimens can be found bearing fruits the size of a child's head, and when ripe, with rich, soft, and most palatable aromatic flesh, that can be readily eaten out with a spoon. What is the use of wasting time in culture of any but these best forms? One does not really know the papaya unless he has eaten the best form of the Dapitan of Zamboanga, or some of the better varieties of Central America. One does not know the sapodilla until he has tried a variety some three inches in diameter, with melting flesh, and a minimum of gum. On hearing some aspersions cast upon the caimito, a valuable and delicious fruit at its best, a Cuban was heard to remark, "There are caimitos, **and there are caimitos!**" A similar remark might be made of most tropical fruits. The methods of seed selection, of breeding, and of vegetative propagation have rarely been brought to bear on any of these things. As for systematic search for the better forms now existing, and the rapid building up of really comprehensive experimental plantations of them in tropical Botanic Gardens, and Experimental Stations, we have yet a field of highly useful, most remunerative, and intensely interesting work before us.

The tropical Botanic Gardens began collections of all the tropical fruits and economics, many years ago. The first seed they obtained was often poor and unselected, representing only one strain, and often an undesirable one at that. In many instances the work has never progressed beyond that first and ineffectual attempt, and in certain instances has led to ill-founded condemnation of certain things for those localities. Yet, as before stated, the Botanic Gardens have accomplished a great work in dissemination, so far as it has gone, but they have a far greater work before them. They keep up continual exchanges of material between themselves, and with private individuals everywhere. But the development of this line of work through this channel alone, as at present operated, can only

take advantage of the existing possibilities in centuries of time. There has been no such thing as systematic coöperative work in the search for, and rapid dissemination of the better varieties. Yet there can be no comprehensive experimentation, no well founded work in breeding or selection without bringing the largest possible percentage of the very best types into experimental plantations together. Out of a large collection of roses taken to Cuba, a large number soon succumbed; a small proportion did fairly well while a very few were great success. Large collections of beans, peas, and other crops, taken to the tropics, commonly furnish but very small percentages of really striking and important successes. How fundamentally important it is then, as each group is taken up for experimentation, that all possible forms obtainable from any source, should be brought into the test together. As it is, we commonly find our stations trying a few from one source this year, some more from another source next year, and so on ad infinitum, with indefinite and scarcely comparable results, that frequently lead nowhere. The very thing that may be able to furnish an immediate success, or to furnish the best basis for breeding or selection or acclimatization work, may not come to hand for an indefinite number of years by this haphazard system.

It is not probable that one-half of the possibilities in acclimatization work have yet been sounded. Even after long reiterated opinions that strawberries, raspberries, grapes, plums, and apples, could never be grown in the tropics, varieties have been found—as well as even wheat—that do fairly well under these conditions, and must eventually do very well with careful selection and breeding. The discovery of native species of Rubus, Prunus, and Vitis in warm countries greatly increases these possibilities, and fills them with horticultural interest.

Private individuals and government gardens rarely have sufficient funds available, to make appreciable headway in any comprehensive effort. But surely the world is enough civilized now, and surely there is sufficient recognition of common interests among the peoples of tropical countries and colonies, for coöperative systematic work to be undertaken, that shall insure the rapid spreading of the horticultural dragnet in every tropical region of earth. The United States Department of Agriculture, with its splendidly effective foreign service, recognizes the tropical work merely as one of its subsidiary interests. Union and coöperation are demonstrated possibilities in the new International Institute of Agriculture in Rome. Tropical countries uniting and subscribing even very modestly for comprehensive field work and distribution to subscribers of abundant material in all required groups, could quickly put into operation an efficient service that would carry forward tropical horticultural and agricultural development by leaps and bounds.